CLAIMS

What is claimed is:

1.   An apparatus for providing a fail-operational global time reference for a redundant synchronous data bus system including a first primary data bus, a second primary data bus, a first redundant data bus, and a second redundant data bus, the apparatus comprising:

a first plurality of timing servers cross-coupled to said first data buses and configured to receive timing synchronization signals from said second primary data bus;

a second plurality of timing servers cross-coupled to said second data buses and configured to receive timing synchronization signals from said first primary data bus; and

a unique constant stored in each timing server,

wherein each said timing server of said first and second pluralities of timing servers is configured to independently and automatically execute a selection protocol responsive to a failure of a timing master to select one timing server from among the first and second pluralities of timing servers to be a replacement timing master based upon synchronization signals received from at least one timing server of said first and second pluralities of timing servers and upon a relationship among said unique constants stored in said timing servers.

2.   The apparatus of claim 1, wherein each said timing server is configured to produce a timing master synchronization signal when selected as timing master.

3.   The apparatus of claim 1, wherein each said timing server includes a counter.

4.   The apparatus of claim 3, wherein each said timing server is configured to transmit, receive, and monitor synchronization signals from each of said first and second pluralities of timing servers and wherein each said counter is responsive to a monitored failure of said timing master synchronization signal to initiate counting from a starting point to count toward each respective stored unique constant.

5.   The apparatus of claim 4, wherein each said timing server is further configured to transmit a master timing synchronization signal when said counter in said timing server has completed counting to said unique constant stored in said timing server.

6.   The apparatus of claim 1, wherein each said timing server is configured to self test its timing synchronization signal.

7.   The apparatus of claim 1, wherein each said timing server is configured to test the timing synchronization signals of other timing servers.

8.   A timing server for providing a fail-operational global time service for a synchronous data bus system interconnecting at least one plurality of timing servers coupled to at least one data bus in said synchronous data bus system, the timing server comprising:

a first module configured to transmit synchronization signals and to receive and monitor synchronization signals from each timing server of said at least one plurality of timing servers;

a second module configured to store a unique constant; and

a third module configured to independently and automatically select one or more timing servers from among the at least one plurality of timing servers to be timing masters based at least partially upon a relationship among unique constants associated with each timing server and upon said synchronization signals received from one or more of said timing servers of said at least one plurality of timing servers.

9.   The timing server of claim 8, wherein said third module is further configured to synchronize to said synchronization signal from said timing master upon first reception of said synchronization signal from said timing master.

10.   The timing server of claim 8, wherein said third module is further configured to transmit a timing master synchronization signal responsive to receiving timing master synchronization signals from two or more other timing servers for more than a predetermined period of time.

11.   An apparatus for providing a fail-operational global time service for a synchronous data bus system interconnecting at least one plurality of timing servers coupled to at least one data bus in said synchronous data bus system, wherein:

each said timing server of the at least one plurality of timing servers is initially configured to transmit synchronization signals and to receive and monitor synchronization signals from each timing server of said at least one plurality of timing servers;

each said timing server of the at least one plurality of timing servers is configured to store a unique constant; and

each said timing server of the at least one plurality of timing servers is configured to independently and automatically select one or more timing servers from among the at least one plurality of timing servers to be timing masters based upon said synchronization signals received from one or more of said timing servers of said at least one plurality of timing servers and based upon a relationship among said unique constants stored in each timing server.

12.   The apparatus of claim 11, wherein each said timing server of the at least one plurality of timing servers is further configured to synchronize to said synchronization signal from said timing master upon first reception of said synchronization signal from said timing master.

13.   The apparatus of claim 12, wherein each said timing server of the at least one plurality of timing servers is further configured to transmit a timing master synchronization signal responsive to receiving timing master synchronization signals from two or more other timing servers for more than a predetermined period of time.

14.   The apparatus of claim 11, wherein each said timing server of the at least one plurality of timing servers is further configured to:

count toward a unique predetermined constant in response to detection of a failure of the timing master synchronization signal to which said each timing server is synchronized;

if no other timing master synchronization signal is received before said counting reaches said unique predetermined constant, transmitting a timing master synchronization signal; and

if a timing master synchronization signal is received before said counting reaches said unique predetermined value, synchronizing to said received timing master synchronization signal.

15.   A method of selecting a timing master in a fail-operational global time reference in a synchronous data bus system having at least one plurality of timing servers coupled to at least one data bus of said synchronous data bus system, one said timing server acting as a timing master, the method comprising the steps of, in each operable timing server of the at least one plurality of timing servers:

detecting a failure of the timing master synchronization signal;

counting toward a unique predetermined constant in response to detection of the failure of the timing master synchronization signal;

if no other timing master synchronization signal is received before said counting reaches said unique predetermined constant, transmitting a timing master synchronization signal; and

if a timing master synchronization signal is received before said counting reaches said unique predetermined value, synchronizing to said received timing master synchronization signal.

16.   The method of claim 15, further comprising a timing master responding to reception of a timing master synchronization signal from another timing server by the step of ceasing to produce a timing master synchronization signal after a predetermined period of time.

17.   The method of claim 15, further comprising the step of transmitting a timing master synchronization signal in response to receiving timing master synchronization signals from two or more timing servers for a period longer than a predetermined period.

18.   The method of claim 15, further comprising the step of performing one or more tests on synchronization signals received from each timing server of the plurality of timing servers and adapting said one or more tests responsive to one or more failed tests.

19.   A method executed in a local timing server coupled to at least one data bus, the method comprising the steps of:

monitoring a timing master synchronization signal from a first remote timing server;

counting toward a unique constant in response to detecting a failure of said timing master synchronization signal in said monitoring step; and

synchronizing to a second remote timing server as timing master if a master timing synchronization signal is received from said second remote timing server during the counting step and otherwise transmitting a timing master synchronization signal.

20.   The method of claim 19, further comprising the steps of:

receiving a second master synchronization signal from a third remote timing server; and

synchronizing to said third remote timing server as timing master.

21.   The method of claim 20, further comprising the step of said local timing server ceasing to transmit the timing master synchronization signal.

22.   The method of claim 19, wherein two timing master signals from said second and third remote timing servers are received for more than a predetermined amount of time, the method further comprising the steps of:

counting toward said unique constant; and

synchronizing to a fourth remote timing server as timing master if a master timing synchronization signal is received from said fourth remote timing server during the counting step and otherwise transmitting a timing master synchronization signal.

23.   The method of claim 19, wherein a timing master synchronization signal is no longer being received, the step of counting further comprising the steps of operating said local timing server automatically and independently until said synchronizing step.

24.   The method of claim 19, further comprising the steps of:

monitoring the synchronization signal from each timing server; and

determining failure of timing synchronization signals from remote timing servers based at least in part on the step of monitoring.

25. The method of claim 24, further comprising the steps of:

comparing an actual time of arrival of a first synchronization signal to the designed time of arrival of the first synchronization signal and to a predetermined tolerance; and

determining that the timing server has failed if a difference between the actual time of arrival of the first synchronization signal and the designed time of arrival of the first synchronization signal exceeds the predetermined tolerance.

26. The method of claim 25, further comprising the steps of:

measuring a temporal gap between the time of arrival of said first synchronization signal and the termination time of a prior, second synchronization signal; and

determining whether the first synchronization signal or the second synchronization signal has failed based, at least in part, on the size of said gap.

27. The method of claim 19, further comprising the steps of:

monitoring timing parameters of the local timing server to determine internal timing integrity; and

determining failure of said local timing server based at least in part on the step of monitoring timing parameters of the local timing server.

28. The method of claim 27, wherein each timing server is designed to produce a frame tick periodically to within a frame tick tolerance, the step of monitoring further comprising the steps of:

comparing an actual frame tick period with the designed frame tick period and said frame tick tolerance; and

determining that said timing server has failed if a difference between the actual frame tick period and the designed frame tick period exceeds the frame tick tolerance.

29.   A program product, comprising: ⸦

A)   a set of instructions executable by a timing server to automatically and independently select a timing master from among a plurality of identically instructed timing servers coupled to at least one bus in a synchronous data bus system, wherein said selection is made based upon time synchronization signals received by said timing server and further based upon a constant unique to each said timing server; and

B)   signal-bearing media bearing the set of instructions.

30.   The program product of claim 29, wherein said signal-bearing media comprises a memory in a timing server.